CASE Study

Designing State-of-the-Art Personal Electronics Power Adapters

by JOHN JOVALUSKY, POWER INTEGRATIONS INC

the challenge

The personal electronics market is extremely competitive. One of the main ways that OEMs differentiate themselves is by making their product the most feature rich, smallest, and lightest. However, many of these devices come with a low-tech, bulky and inefficient linear transformer based brick adapter or charger. Recently, manufacturers have begun to differentiate their products by providing smaller and lighter power supplies with their devices to meet tighter energy efficiency regulations.

A high-end personal gaming device manufacturer chose to enclose a 16-watt power adapter into an ultra-low profile case. Power Integrations' (PI) Applications Engineering group produced the only solution that met all of the customer's specifications including the daunting height limit, EMI, thermals, and the new mandatory California Energy Commission (CEC) no-load power consumption and active efficiency standards.

Goal: Design an 8.3 W/in^3,10 mm high, universal input AC-DC power adapter

Designing high-density power supplies can be challenging, but when the height of the entire solution is limited to a mere 10 mm and it must be encased in a small sealed enclosure, the task is much more difficult. Meeting both conducted and radiated EMI limits, while adequately dispersing the supply's internal heat—to eliminate hot spots that could exceed the Safety Agency's plastic touch temperature—were the toughest challenges that the PI Applications Engineers faced in this design.

the solution

The Design process

First, some critical decisions about converter topology, PI product family, and the device were made. Since the maximum output current was only three amps, the Flyback topology was chosen to minimize the overall solution cost.

IC Family and Device Selection

The TOP245P, a member of the TOPSwitch®-GX family, was selected to take advantage of its low cost 8 pin DIP package, and its many integrated features. To meet the 10 mm height criteria, an extremely low profile transformer and EMI choke were required. Setting the TOP245P switching frequency to 132 kHz allowed the use of an appropriate transformer. The simple resistor programming of the device's external current limit (M pin) function provided true overload power limiting by reducing the MOSFET current limit proportionally to the input line voltage. The overload power limiting and the device's auto-restart function allowed the transformer secondary winding, output diode D1, and the output capacitor C9 to be sized for full load current only, instead of some higher value of overload current. This reduced the amount of PCB copper required to heat sink D1.

CUSTOMER PROFILE

A LEADING PROVIDER OF POWER AND ACCESSORY SOLUTIONS FOR GLOBAL PERSONAL ELECTRONICS OEMs.

Designing to Meet EMI

Despite the high power density, both conducted and radiated, EMI limits were met with sufficient margin (10 dB) without the use of any X capacitors. This was due to a number of factors, the first being the switching frequency jitter feature of the TOP245P. The device modulates its switching frequency by ± 4 kHz, at a 250 Hz rate, effectively spreading out the switching noise over a wide frequency range, which lowers both the average and quasi-peak EMI measurements.

Because of the frequency jittering, a simple Pi filter that consists of the two input capacitors and a small common mode choke (C1, C2, and L2) adequately attenuates conducted EMI. Only an additional small differential mode choke (L1) was required to meet the worst case limits. A small Y capacitor (C4) was used to suppress EMI generation around the transformer. A RCD clamp (R5, R6, R7, C3, and D2) and a RC snubber (C7 and R9) sufficiently limited the EMI from both the drain node Flyback voltage spike and the output diode commutation reverse recovery, without lowering the overall efficiency significantly.

Lastly, the transformer was strategically designed using proprietary winding techniques to minimize EMI. Low leakage inductance minimized the energy in the Flyback spike that is induced when the MOSFET turns off. The turns ratio and wire gauge sizes of the windings were also carefully chosen to lower the reflection of the output voltage on the primary side, further reducing EMI, while lowering the RMS current in the output diode. This minimized its dissipation, and kept the overall efficiency high.

Managing Heat Dispersion

The DIP package of the TOP245P was designed to disperse heat into the PCB copper through its package pins. This eliminates the need for an installed heatsink. Since the main switch and the output diode are typically the warmest components in a power supply, heat spreaders were placed over them to prevent them from becoming hot spots.

Balancing EMI and Thermals

Transformer design was an intricate part of keeping EMI low and efficiency high. Because circuits, such as the primary drain node clamp, the output diode snubber and even the input EMI filter chokes are dissipative, the harder they have to work, the more they lower the operating efficiency of the power supply. It was imperative to minimize transformer EMI generation, not only to meet the regulation limits with good margin, but also to keep the efficiency high, making thermal management in a sealed enclosure feasible, without resorting to exotic measures like thermal pads.

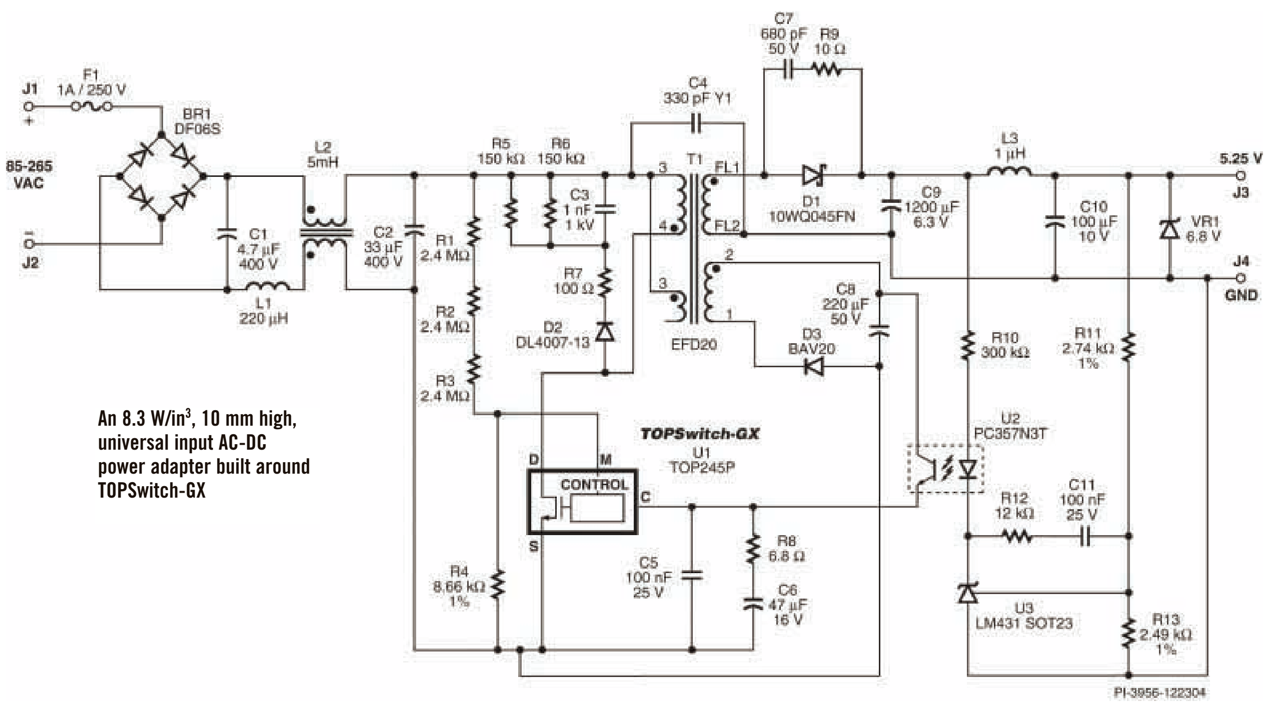
Power Integrations Conclusion Points

Selecting the right topology and switching IC from the start are critical to successfully designing high-density, high efficiency power supplies that meet thermals and EMI.

Choosing a switching IC that has the most commonly used functions integrated into it makes high-density designs possible, by minimizing the overall parts count. This production worthy power supply uses only 35 components.

Since Power Integrations' ICs all have its patented EcoSmart® technology inside, this design easily met the new CEC external power supply no-load and efficiency requirements.

Power Integrations supplies its customers with the most highly integrated, high-voltage, monolithic power supply ICs, and can help them design low cost, robust, high density power supplies, even really challenging ones. ■



An 8.3 W/in³, 10 mm high, universal input AC-DC power adapter built around TOPSwitch-GX